**Simpson’s Index of Diversity of insect pests and natural enemies inhabiting the chickpea, *Cicer* *arietinum* (Linnaeus) agroecosystem in the Kanpur region of Uttar Pradesh (India)**

**ABSTRACT**

An experiment was conducted at the Students’ Instructional Farm (SIF) of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India during 2023-24 and 2024-25. In the Kanpur region of Uttar Pradesh, India, seven species of insect pests and natural enemies were recorded from the chickpea agroecosystem. Among these two species from Lepidoptera, two species from Hymenoptera, one species from Hemiptera, Odonata, and Dictyoptera. Based on economic importance, three species were insect pests, three species were predators and one species was of parasitoid. Among the seven species, *Helicoverpa* *armigera* and *Agrotis* *ipsilon* occurred regularly and gram pod borer was designated as a major pest while, gram cut worm infested with very low population density and considered as minor insect pest of chickpea. One species of insect pest i.e. Cowpea aphid, *Aphis* *craccivora* occurred occasionally and was designated as minor pest. All four species of natural enemies i.e. Dragonfly, Common yellow wasp, Ichneumonid wasp, and Praying mantis occurred occasionally and their status was minor. The relative abundance during both the years *i.e.* 2023-24 and 2024-25, maximum relative abundance was observed for *Aphis craccivora* followed by *H. armigera*, *Crocothemis servilia, Vespa orientalis, Agrotis* *ipsilon*, *Mantis religiosa* and *Campoletis chloridae.* The Simpson’s Index during the years 2023-24 and 2024-25 were 0.47 and 0.51, respectively. The Simpson’s Index of Diversity during the years 2023-24 and 2024-25 was 0.53 and 0.49, respectively.

**Keywords:** Natural enemies; Agroecosystem; Parasitoid; Predators; Sipson’s Index; Simpson’s Index of Diversity

**1. INTRODUCTION**

Chickpea, *Cicer* *arietinum* (Linnaeus), is one of India's most widely produced pulse crop, accounting for 40% of the country’s total pulse production. Globally, chickpea is cultivated on 15 million hectares, producing over 18.1 million tonnes during 2022-23. India is the largest producer of chickpeas in the world with 13.75 million tonnes from an acreage of 10.91 million hectares, with a productivity of 10.12 quintals per hectare. Though India is the largest producer, it stands at 8th position in productivity with 1012 kg per hectare. Chickpea contribute nearly 50% of India’s pulse production. The major producing states are Maharashtra (2.631 million hectares), Madhya Pradesh (2.346 million hectares), Rajasthan (1.938 million hectares), Uttar Pradesh (0.682 million hectares), Karnataka (0.962 million hectares) and Gujrat (0.631 million hectares). In Uttar Pradesh chickpea is grown in an area of 0.62 million hectares with production of 0.77 million tonnes and productivity of 1250 kg/ha in 2023-24. Maharashtra is the country's single largest producer, accounting for over 23.82 percent of total production while Madhya Pradesh, Rajasthan, and Uttar Pradesh contribute about 22.05 percent, 19.28 percent, and 5.59 percent, respectively. According to the government’s 3rd advance estimates, all India chickpea production in 2023-24 is 115.76 lakh tonnes **(Anonymous 2023-24)**.

It is a rich source of nutritional values in the diet of Indian people because of containing 21.5 per cent protein, 64.5 per cent carbohydrates and 4.5 per cent fat which is comparatively deficient in the cereals and oilseeds. Its green leaves and pods are used as green vegetables and germinated grains for breakfast and other delicious dishes by the people in their daily meals **(Parmar *et al.,* 2015)**.

Chickpea play an important role in the vegetarian diet as a major source of protein. It is consumed as a green vegetable, *dal*, *chhole*, germinated breakfast food, and powder to prepare sweets and many other relishing dishes. Its leaves are consumed both raw and cooked to take advantage of malic acid, citric acid, mineral matter, and fiber, which have medicinal properties. Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Gujrat, Andhra Pradesh, and Karnataka are the major chickpea-producing states sharing over 95 percent area of chickpea production. Various factors responsible for the low production and productivity of chickpea are poor genetic base, weeds, diseases, and insect pests. Major insect pests of chickpea are Gram Pod Borer, *Helicoverpa* *armigera* (Hubner), cutworm, *Agrotis* *ipsilon* (Hufnagel), Gram semilooper, *Autographa* *nigrisigna* (Walker), Aphid, *Aphis* *craccivora* (Koch) and Tur pod bug, *Clavigralla* *gibbosa* (Spinola**) (Sithanantham *et al.,* 1984)***.*

Chickpea is attacked by more than 25 species of insects and of them gram pod borer, *Helicoverpa* *armigera* (Hubner) and gram cut worm, *Agrotis* *ipsilon* (Hufnagel) are of importance of national significance and six insect pests *i.e.* bean aphid, *Aphis* *cracciovora* (Koch), semilooper, *Autographa* *nigrisigna* (Walker), tobacco caterpillar, *Spodoptera* *litura* (Hubner), pod bug, *Riptortus* *pedestris* (Fab.) and leaf webber, *Eucosma* *critica* are major pest of regional significance **(Sharma *et al.,* 2020).**

**2. MATERIALS AND METHODS**

**2.1 Qualitative diversity:**

The experiments on different aspects were conducted under field conditions at the Students’ Instructional Farm (SIF) of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India.

The appearance of insect pests and their natural enemies including predators and parasitoids inhabiting the chickpea agroecosystem were observed at weekly intervals from the seedling stage of the chickpea to the maturity of the crop. The chickpea variety KGD-1168 was sown in the plot size of 10 × 10 m by adopting 30 cm row-to-row and 10 cm plant-to-plant spacing during the winter season of 2023-24 and 2024-25. The incidence of insect pests and natural enemies was observed visually at weekly intervals throughout the cropping season. The qualitative diversity of insect pests and their natural enemies was categorized into different groups based on their occurrence. The insect pests and natural enemies that infested the crop continuously after their first appearance in considerable numbers were designated as major and those that occurred intermittently and had a population never became high were categorized as minor, while the species, whose occurrence was scarce with a very low population was designated as stray.

**2.2 Relative Abundance:**

Observations were regularly monitored at weekly intervals for recording the different insects. The number of insects were recorded on ten randomly selected plants from the 10 × 10 m plot by following mode of observations as follows:

*H. armigera* and *A. ipsilon* (Number of larvae on 10 randomly selected plants). *Aphis* *craccivora* (Number of aphids per 10 cm on ten randomly selected plants). Population of natural enemies was recorded on ten randomly selected plants by visual count and sweep net. For sweep net method about 5 strokes of sweeping were made. After each stroke, the predators caught in the net were counted. Total number of individuals of each species observed throughout the cropping season was used to calculate the relative abundance and Simpson’s Index of Diversity.

The relative abundance of insect pests and natural enemies was calculated by the following formula:

Relative abundance (%) = $\frac{No. of insect pests or natural enemies}{No. of individuals of all species } ×100$

**2.3 Simpson’s Index (D):**

Species or alpha diversity of the site was quantified by using Simpson’s Index (D), **(Simpson, 1949)**. Simpson’s Index (D) is a measure of diversity that takes into account the number of species present as well as the relative abundance of each species. Simpson’s Index (D) was calculated by using the following formula:

D =$ \frac{ Σn(n-1)}{N(N-1)}$

Where,

N = Total no. of individuals of all species (insect pests and natural enemies).

n = Total no. of individuals of a particular species.

**2.4 Simpson’s Index of Diversity (SID):**

Subtracting the value of Simpson’s Index (D) from 1 resulted in Simpson’s Index of Diversity (SID). The value of SID ranges from 0 to 1. The greater SID value will represent greater sample diversity.

Simpson’s Index of Diversity = 1 – D

Where,

D = Simpson’s Diversity Index

The infestation of insect pests at different crop growth stages (Crop phenology) i.e. succession of insect pests was also recorded from the seedling stage to the crop maturity stage.

**3. RESULTS AND DISCUSSION**

A list of various insect-pests and their natural enemies inhabiting chickpea agroecosystem during winter of 2023-24 and 2024-25 cropping season is presented in Table 1. The seven species of insect pests and natural enemies of different groups were observed from chickpea agroecosystem during both the cropping season. The diversity of insect pests and natural enemies were categorized in different groups *i.e.* pest, predator and parasitoid on the basis of their feeding behavior. On the basis of occurrence, those insect pests and natural enemies which occurred on the crop continuously after their first appearance in considerable numbers were designated as regular occurrence, while those insect pests and natural enemies whose population occurred intermittently or otherwise disappear before harvest were categorized as occasional occurrence.

The perusal of qualitative diversity of insect pests and natural enemies inhabiting chickpea agroecosystem (Table 1) revealed that seven species belonging to five orders and six families were recorded throughout the cropping period of chickpea during 2023-24 and 2024-25. Based on total number of species, order Lepidoptera (two species), order Hymenoptera (2 species), order Hemiptera (1 species), order Odonata (1 species) and order Dictyoptera (1 species) were observed. On the basis of economic importance, the diversity of insect pests and natural enemies were observed as pests (3 species), insect predators (3 species) and insect parasitoids (1 species) from chickpea cropping system were observed.

Among the three species of insect-pests two were designated as regular in occurrence *i.e.* gram pod borer, *Helicoverpa* *armigera* (Hubner) (Lepidoptera: Noctuidae) and gram cut worm, *Agrotis* *ipsilon* (Hufnagel) (Lepidoptera: Noctuidae), one species was designated to occurred occasionally *i.e.* cowpea aphid, *Aphis* *craccivora* (Koch) (Hemiptera: Aphididae). Among two regular pests, gram pod borer, *Helicoverpa* *armigera* (Hubner) was noticed as major insect pest of chickpea which infested both vegetative and reproductive growth phase of chickpea crop, while gram cut worm, *Agrotis* *ipsilon* (Hufnagel) occurred regularly on chickpea (vegetative stage) with low population density and considered as minor insect pest of chickpea. Among occasional pest, cowpea aphid, *Aphis* *craccivora* (Koch) also occurred in low population density was also considered as minor pest.

The qualitative diversity of natural enemies (predators and parasitoids) inhabiting chickpea agroecosystem (Table.1) revealed that four species of natural enemies (three species of predators and one species of parasitoid) were observed in chickpea crop occasionally in low population density and designated as minor status. The maximum number of natural enemies was of the order Hymenoptera (one species of predator and one species of parasitoid) *i.e.* common yellow wasp, *Vespa* *orientalis* (L.) (Hymenoptera: Vespidae) and Ichneumonid wasp, *Campoletis* *chloridae* (Uchida) (Hymenoptera: Ichneumonidae). Among natural enemies one species from order Odonata *i.e.* Dragonfly, *Crocothemis* *servilia* (Drury) (Odonata: Libellulidae) and one species from order Dictyoptera *i.e.* Praying mantis, *Mantis* *religiosa* (L.) (Dictyoptera: Mantidae) occurred occasionally with minor status.

**Relative Abundance and Diversity Index**

A list of various species and their relative abundance in chickpea agroecosystem during winter2023-24 and 2024-25 cropping season is presented in Table 2.

During the cropping season 2023-24, highest number of individuals were recorded of *Aphis craccivora* (Koch) (325 individuals) followed by *Helicoverpa armigera* (Hubner) (105 individuals), *Crocothemis servilia* (Drury)(26 individuals), *Vespa orientalis* (L.) (17 individuals), *Agrotis* *ipsilon* (Hufnagel) (12 individuals), *Mantis religiosa* (L.)(6 individuals) and lowest number of individuals were recorded of *Campoletis chloridae* (Uchida)(5 individuals) throughout the cropping season. The relative abundance among all the species was found to be highest for *Aphis craccivora* (Koch) (65.52%) followed by *Helicoverpa armigera* (Hubner) (21.16%), *Crocothemis servilia* (Drury)(5.24%), *Vespa orientalis* (L.)(3.42%), *Agrotis* *ipsilon* (Hufnagel)(2.41%), *Mantis religiosa* (L.) (1.20%) and lowest relative abundance was recorded for *Campoletis chloridae* (Uchida)(1.00%) for the whole cropping season. Simpson’s Index (D) was 0.47 and Simpson’s Index of Diversity (SID) was 0.53 during the cropping season 2023-24.

During the cropping season 2024-25, highest number of individuals were recorded of *Aphis craccivora* (Koch) (418 individuals) followed by *Helicoverpa armigera* (Hubner) (122 individuals), *Crocothemis servilia* (Drury)(22 individuals), *Vespa orientalis* (L.) (19 individuals), *Agrotis* *ipsilon* (Hufnagel) (15 individuals), *Mantis religiosa* (L.)(8 individuals) and lowest number of individuals were recorded of *Campoletis chloridae* (Uchida)(7 individuals) throughout the cropping season. The relative abundance among all the species was found to be highest for *Aphis craccivora* (Koch) (68.41%) followed by *Helicoverpa armigera* (Hubner) (19.96%), *Crocothemis servilia* (Drury)(3.60%), *Vespa orientalis* (L.)(3.10%), *Agrotis* *ipsilon* (Hufnagel)(2.45%), *Mantis religiosa* (L.) (1.30%) and lowest relative abundance was recorded for *Campoletis chloridae* (Uchida)(1.14%) for the whole cropping season. Simpson’s Index (D) was 0.51 and Simpson’s Index of Diversity (SID) was 0.49 during the cropping season 2024-25.

The results are in accordance with the findings of **Namdev *et al.* (2024)** who reported seven species of insects belonging to five orders and six families were recorded from chickpea agroecosystem. Among which two species were from Lepidoptera, two species from Hymenoptera, one species from Odonata, Hemiptera and Dictyoptera were identified. The results are also in accordance with **Sharma *et al.* (2020)** who reported chickpea is infested by twenty-five species of insects, among which three *i.e.* gram pod borer, *Helicoverpa* *armigera* (Hub.), cutworm, *Agrotis* *ipsilon* (Huf.) and termite, *Odontotermes* *obesus* (Ramb.) insect pests are major importance of national significance and six insect pests *i.e.* bean aphid, *Aphis* *craccivora* (Koch), semilooper, *Autographa* *nigrisigna* (Walker), tobacco caterpillar, *Spodoptera* *exigua* (Hub.), pod bug, *Riptortus* *pedestris* and leaf webber, *Eucosma* *critica* are major pests of regional significance. The ecological factors are known to affect the occurrence and severity of insect pests. The maintenance of biodiversity and variability of insect fauna within agricultural environment is widely recognized as being essential for their agronomic sustainability. However, a previous study conducted by **Singh *et al.* (2018)** and **Sharma *et al.* (2020)** observed that chickpea pod borer, *Helicoverpa* *armigera* and gram cut worm, *Agrotis* *ipsilon* are major pests of chickpea in Uttar Pradesh and Madhya Pradesh, respectively. The earlier report made by **Sharma *et al.* (2000)** reported that Lepidoptera was the largest order of insect pests infesting chickpea at Jabalpur, Madhya Pradesh, India. Among insect pest five species were observed to occur occasionally *i.e.* armyworm, *Mythimna* *seperata* (Walker), tobacco caterpillar, *Spodoptera* *litura* (Fab.), cowpea aphid, *Aphis* *craccivora* (Koch), termite, *Odontotermes* *obesus* (Rambur) and black flea beetle, *Altica* species recognized as minor insect pests of chickpea. The findings are also in accordance with the observations made by **Singh *et al.* (2018)** who reported that *Campoletis* *chloridae* (Uchida) occurred predominantly in chickpea ecosystem in Kanpur region of Uttar Pradesh, India.

**Table 1 Qualitative diversity of insect pests and natural enemies in the chickpea agroecosystem duringwinter, 2023-24 and 2024-25**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Common Name** | **Scientific Name** | **Order:****Family** | **Occurrence** | **Status** | **Crop Stage** | **Nature** |
| **2023-24** | **2024-25** | **2023-24** | **2024-25** |
| 1 | Gram pod borer | *Helicoverpa armigera* (Hub.) | Lepidoptera:Noctuidae | Regular | Regular | Major | Major | Vegetative & reproductive stage | Pest |
| 2 | Gram cut worm | *Agrotis ipsilon*(Hufnagel) | Lepidoptera:Noctuidae | Regular | Regular | Minor | Minor | Vegetative stage | Pest |
| 3 | Cowpea aphid | *Aphis craccivora* (Koch) | Hemiptera:Aphididae | Occasional | Occasional | Minor | Minor | Vegetative & reproductive stage | Pest |
| 4 | Dragonfly | *Crocothemis servilia* (Drury) | Odonata:Libellulidae | Occasional | Occasional | Minor | Minor | Vegetative & reproductive stage | Predator |
| 5 | Common yellow wasp | *Vespa orientalis* (L.) | Hymenoptera:Vespidae | Occasional | Occasional | Minor | Minor | Flowering stage | Predator |
| 6 | Ichneumonid wasp | *Campoletis chloridae* (Uchida) | Hymenoptera:Ichneumonidae | Occasional | Occasional | Minor | Minor | Flowering stage | Parasitoid |
| 7 | Praying mantis | *Mantis religiosa* (L.) | Dictyoptera:Mantidae | Occasional | Occasional | Minor | Minor | Vegetative & reproductive stage | Predator |

**Table 2 Relative abundance and Diversity Index of insect pests and natural enemies during *Rabi*, 2023-24 and 2024-25**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **Insect pests and natural enemies** | **2023-24** | **2024-25** |
| **Total no. of insect pests and natural enemies** | **Relative abundance (%)** | **Total no. of insect pests and natural enemies** | **Relative abundance (%)** |
| 1 | *Helicoverpa armigera* (Hub.) | 105 | 21.16 | 122 | 19.96 |
| 2 | *Agrotis ipsilon* (Hufnagel) | 12 | 2.41 | 15 | 2.45 |
| 3 | *Aphis craccivora* (Koch) | 325 | 65.52 | 418 | 68.41 |
| 4 | *Crocothemis servilia* (Drury) | 26 | 5.24 | 22 | 3.60 |
| 5 | *Vespa orientalis* (L.) | 17 | 3.42 | 19 | 3.10 |
| 6 | *Campoletis chloridae* (Uchida) | 5 | 1.00 | 7 | 1.14 |
| 7 | *Mantis religiosa* (L.) | 6 | 1.20 | 8 | 1.30 |
| **Simpson’s Index (D)** | **0.47** | **0.51** |
| **Simpson’s Index of Diversity (SID)** | **0.53** | **0.49** |

**Figure.1 Relative abundance (%) of insect pests and natural enemies during *Rabi*, 2023-24**

**Figure.2 Relative abundance (%) of insect pests and natural enemies during *Rabi*, 2024-25**

**4. CONCLUSION**

In the Kanpur region of Uttar Pradesh, India, seven species of insect pests and natural enemies belonging to five orders and six families were recorded from chickpea agroecosystem. Among seven species two species from Lepidoptera, two species from Hymenoptera, one species from Hemiptera, Odonata and Dictyoptera were identified. On the basis of economic importance three species were insect pests, three species were predators and one species was of parasitoid. Among the three species of insect pests, chickpea pod borer, *Helicoverpa* *armigera* (Hubner) and gram cut worm, *Agrotis* *ipsilon* (Hufnagel) occurred regularly and chickpea pod borer was designated as major pest of chickpea in Kanpur region of Uttar Pradesh, India. While gram cut worm, *Agrotis* *ipsilon* (Hufnagel) infested on vegetative stage with very low population density and was considered as minor insect pest of chickpea. Also, one species of insect pest occurred occasionally *i.e.* cowpea aphid, *Aphis craccivora* (Koch) and was considered as minor pest of chickpea in Kanpur region of India.

The qualitative diversity of natural enemies (predators and parasitoids) inhabiting chickpea agroecosystem observed that four species of insects, among which three species of predators and one species of parasitoid was observed in chickpea crop occasionally in very low population density. The maximum number of natural enemies was of order Hymenoptera, one species of predator and one species of parasitoid *i.e.* Common yellow wasp, *Vespa* *orientalis* (L.) and Ichneumonid wasp, *Campoletis* *chloridae* (Uchida) followed by order Odonata i.e. Dragonfly, *Crocothemis* *servilia* (Drury), order Dictyoptera i.e. Praying mantis, *Mantis* *religiosa* (L.). All the natural enemies occurred occasionally and their status was minor during both the cropping seasons.

Relative abundance of insect pests and their natural enemies during winter, 2023-24 and 2024-25 revealed that maximum relative abundance was recorded in *Aphis* *craccivora* (Koch), followed by *Helicoverpa* *armigera* (Hubner), *Crocothemis* *servilia* (Drury), *Vespa* *orientalis* (L.), *Agrotis* *ipsilon* (Hufnagel), *Mantis* *religiosa* (L.) and minimum relative abundance was observed for *Campoletis* *chloridae* (Uchida).

Simpson’s Index (D) during winter, 2023-24 and 2024-25 was 0.47 and 0.51, respectively. Simpson’s Index of Diversity (SID) during winter, 2023-24 and 2024-25 was 0.53 and 0.49, respectively.

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